Description

Allocation of station addresses to communication users in a bus
system

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The invention relates to a method for allocation of station
addresses to communication users in a bus system, and
communication users in a bus system.

10   The bus system has generally come to predominate in digital
technology for the transfer of information between individual
users in a system, in other words communication between users.
A bus system is characterized in that several communication
users are connected on the input side and/or output side in
15   parallel to a shared bus. A bus system is thus a device for
collective communication between several users, each user being
able to associate with every other user directly. A distinction
is made between parallel and serial bus systems. Data is mostly
exchanged on a bit-parallel and byte-serial basis, but bit-
20   serial operation is also possible. Depending on the variant,
these are known as parallel or serial bus systems. Bit-parallel
buses are preferably used for transmitting high data rates over
short distances, e.g. within a computer. The merits of bit-
serial buses lie in the small outlay for drivers, connectors
25   and transmission lines (often simple two-wire lines). Data
transmission is unproblematic even over large distances and the
hardware requirement for any electrical isolation needed is
comparatively small.

30   Communication users in a bus system, e.g. communication users
linked to a serial bus, normally require a unique station
address to be able to communicate with one another. In the past
various methods have been used with serial bus systems to

assign station addresses for the individual communication
users. Normally this involves a manual setting via coding
switches at the communication users or assigning an address in
advance via the bus, whereby it must be possible to address
5   every communication user from the outset. In other customary
methods the station address is arrived at on the basis of the
position of the communication user on the bus. The data traffic
in such a system is generated by what is known as a bus master,
to which the structure of the bus must be known. Address
10 conflicts cannot occur in such a case. The bus master generates
a precisely specified data frame which has as many data fields
as the number of data users connected on the bus. This data
frame is sent from one communication user to the next, each
user being able to extract its data and to send new data for
15 the bus master. This method is particularly problematic if a
communication user has to be exchanged and the bus master does
not recognize this change immediately. As a result the data
frame is displaced and specific data no longer reaches the
right recipient. The methods described for assigning addresses
20 are either very prone to error, like manual assignment with
coding switches, or already require a uniqueness attribute for
the individual communication users before the address can be
assigned. This uniqueness attribute must be known to both the
address assignment unit and the communication users.
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The object of the invention is to simplify the allocation of
station addresses to communication users in a bus system.

This object is achieved by a method for allocating station
30 addresses to communication users in a bus system, whereby
exactly one first communication user able to transmit
automatically on a bus can allocate to a station address data
that uniquely identifies another communication user, or a

station address can be characterized as non-occupied, in which
method in each communication cycle

- the first communication user in each case sends a first data
  packet to each station address, whereby the first data
5 packet if necessary contains data allocated to the
  respective station address, said data uniquely identifying
  another communication user,

- one or more other communication users each send the first
  communication user a second data packet containing their
10 station address and data uniquely identifying the respective
  other communication user, whereby the data uniquely
  identifying the respective other communication user is
  allocated to the respective station address by the first
  communication user and

15 • the first communication user sends all other communication
  users a third data packet containing the information about
  which station addresses are characterized as non-occupied,
  whereby a communication user that in an earlier communication
  cycle already sent the first communication user a second data
20 packet containing data uniquely identifying this communication
  user and that in a subsequent communication cycle receives a
  first data packet containing data not uniquely identifying this
  communication user automatically alters the station address
  thereof to one of the station addresses characterized as non-
25 occupied.

This object is achieved by a communication user in a bus system
which can automatically transmit on a bus and has means for
allocating to a station address data uniquely identifying
30 another communication user and means for characterizing a
station address as non-occupied.

This object is achieved by a communication user in a bus system
which has means for sending a first communication user second
data packets containing data uniquely identifying the
communication user and which can automatically alter the
5   station address thereof.

The invention is based on the idea of having communication
users themselves undertake the assignment of station addresses
to communication users in a bus system, in particular in a
10   serial bus system, using centrally available information. The
inventive method ensures that the station addresses of the
communication users are unique. Multiply assigned station
addresses are automatically identified and address conflicts
that occur are resolved locally by the affected communication
15   users automatically by randomly selecting a potentially free,
non-occupied station address. This thus involves a method for
autoconfiguration of station addresses. Already assigned
station addresses of addressable communication users are not
affected by this. Thus all communication users can be reached
20   and addressed. The method does not involve a central assignment
of station addresses, but it can form the prerequisite for
this. In the inventive method all valid physical station
addresses in the bus system can be used completely freely.
There is no need for relationships, for example with the
25   physical position of the communication user, nor is the address
space in any way restricted. The method does not require
additional wiring between the communication users or particular
restrictions as regards the topology. It can be applied to the
bus topology finally set up for an operation. Since the station
30   address is administered by the communication user itself,
disruptions or addressing errors are ruled out even when a
communication user is exchanged, e.g. when a module is
exchanged.

Mixed configurations with communication users having no means for transmitting to a first communication user second data packets containing data uniquely identifying the respective
5 communication user and not being able to automatically change their station address are possible without negatively affecting these communication users.

The communication cycle is repeated with a particular cycle
10 duration. In order to burden communication resources as little as possible with sending, forwarding, receiving and processing the data packets required for the allocation of station addresses to communication users, it is proposed in accordance with an advantageous embodiment of the invention that the cycle
15 duration of the communication cycle is variable. Thus the cycle duration can, for example in an initial phase in which the addressing has not as yet progressed very far, be selected to be smaller in comparison to a later phase in the addressing procedure in which there is less need for addressing. In
20 particular, following a successful conclusion of the allocation of station addresses to communication users the described communication cycle can be performed only with a comparatively large cycle duration in comparison to other communication cycles, in order for example to be able to respond to changes
25 in the bus system as a result of the exchange or failure of communication users and the like.

On the basis of the inventive method for allocating station addresses to communication users in a bus system an
30 advantageous embodiment of the method is proposed, in which device information can be stored in storage means of the other communication users, it being possible for the storage means to be addressed via the bus by the first communication user and

for the device information to be read out by the first communication user. Thus for example all device information needed for an automatic configuration can be stored directly in a memory of the other communication users. For reading out, a
5 message-oriented transmission method, as already defined for most serial bus systems, is for example used. Thus an up-to-date picture of the device information of every other communication user located on the bus is available to the first communication user at all times. The device information
10 comprises, for example, an identification and possible configurations and parameterizations.

Thus project planning and maintenance for a bus system is possible without device information supplied by the
15 manufacturer in the form of electronic data sheets. Thus it is possible to automate further steps in the project planning of a bus system, in particular of a serial bus system. When using this advantageous embodiment of the invention a comparison between the projected communication users with their
20 configuration and parameterization and the situation actually prevailing on the bus is always available to a project planner. Thus project planning errors, errors in wiring and the choice of communication users can be analyzed at a central point and correspondingly rectified.
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The invention is described and explained in more detail below on the basis of the exemplary embodiments shown in the figures.

The figures show:
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Figure 1 a bus system with communication users,

Figure 2 a first data packet,

Figure 3 a third data packet,

Figure 4 the communication between a first communication user
5   and other communication users,

Figure 5 the communication between a first communication user
           and another communication user without an address
           conflict,
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Figure 6 the communication between a first communication user
           and another communication user without means for
           sending second data packets and

15 Figure 7 the communication between a first communication user
           and other communication users when an address
           conflict is present.

Figure 1 shows a serial bus system 9 with communication users
20 1, 2. The communication users 1, 2 are interconnected via a bus
3. A first communication user 1 in the bus system 9 has means 7
for allocating to a station address 6 data uniquely identifying
another communication user 2 and for characterizing a station
address 6 as non-occupied. The first communication user 1 can
25 in each case send a first data packet 4 to each station address
6, the first data packet 4 if necessary containing data
assigned to the respective station address 6 and uniquely
identifying another communication user 2. The other
communication users 2 in the bus system 9 have means 8 for
30 sending the first communication user 1 second data packets 5
containing data uniquely identifying the respective
communication user 2 and can automatically and independently
change their station address 6.

Figure 2 shows a first data packet 10. The first data packet 10 has a first section 11 containing the name of the data packet. Further information on the structure of the first data packet

5 is contained in a second section 12 of the first data packet 10, for example an identification of the data packet and data that uniquely identifies another communication user, such as for example component data and/or a serial number.

10 Figure 3 shows a third data packet 13. The third data packet 13 has a first section 14 containing the name of the third data packet. Further information on the structure of the third data packet 13 is contained in a second section 15 of the third data packet 13. Examples of such information include an

15 identification of the third data packet, status information, information on critical bus parameters and/or information about which station addresses are characterized as non-occupied.

Figure 4 shows the communication between a first communication

20 user, known as the ACFG manager 20, and other communication users, in this case four so-called ACFG agents 22 to 25 (ACFG = autoconfiguration) and another communication user 26. The communication users are therefore each allocated one of two different roles. The ACFG manager 20 assumes the controlling

25 role for the so-called ACFG mechanism. Only one ACFG manager 20 may be active on the bus system at a time. An ACFG manager 20 must be able to transmit automatically on the bus. In bus systems based on the master-slave principle, the ACFG manager 20 must always be a master. Other communication users connected

30 on the bus system can each assume the role of an ACFG agent 22 - 25.

The ACFG manager 20 has, as means for allocating to a station address data uniquely identifying another communication user and for characterizing a station address as non-occupied a database in a memory, known as the system MIB (MIB = Management Information Base). In the system MIB 21 each possible station address in the bus system is allocated either a communication user or the information that this station address is not occupied. The ACFG manager 20 can autonomously send data packets on the bus. Figure 4 shows various data packets. In general data packets are also called PDUs (Protocol Data Units). PDUs sent by the ACFG manager 20 are called request PDUs. PDUs sent by communication users in reply to the request PDUs are called response PDUs.

The ACFG manager 20 initiates a communication cycle, also called an ACFG cycle, in which all station addresses possible in the corresponding serial bus system are addressed. In the exemplary embodiment in Figure 4 a communication cycle for allocating station addresses to communication users is shown by way of example. The chronological sequence of the data packets corresponds in principle to the direction of the time arrow t. At the start of the communication cycle the ACFG manager 20 sends what is known as an SDD request PDU 34 (SDD = Systems Data Distribution) by broadcast 37 to all users in the bus system. The SDD request PDU 34 is an exemplary embodiment of a third data packet 13 in accordance with Figure 3. By means of the SDD request PDU 34 all station addresses characterized as non-occupied are announced by the ACFG manager 20 in the bus system. Each ACFG agent saves in each ACFG cycle the list of free bus addresses contained in the SDD request PDU 34.

The request PDUs illustrated below are what are known as NAN request PDUs 35 - 40 (NAN = New Agent Notification). A NAN

request PDU is an exemplary embodiment of a first data packet 10 in accordance with Figure 2. The NAN request PDU 35 - 40 contains where necessary information uniquely identifying a communication user. The ACFG manager 20 sends a NAN request PDU

5   35 - 40 to every available station address 28 - 33. If the station addresses 28, 30 are not occupied by a communication user, the ACFG manager 20 does not receive a corresponding response PDU to the respective NAN request PDU 35 or 37. In this case the ACFG manager 20 characterizes these station

10   addresses in its system MIB as non-occupied. All station addresses to which no reply is given contain, for example, the entry "free" in the system MIB 21. All station addresses with this entry are simultaneously published as a broadcast message at the start of each ACFG cycle by means of an SDD request PDU

15   34 to all communication users.

If a NAN request PDU 36, 40 is sent to a station address 29 or 33 which is allocated to an ACFG agent 22 or 25 participating in the described procedure, the ACFG manager 20 in each case

20   receives a NAN response PDU 41 or 42 having data uniquely identifying the respective ACFG agent 22 or 25. A station address 29, 33 to which a response is given with such a correct NAN response PDU 41, 41 contains the entry "ACFG agent" in the system MIB 21 of the ACFG manager 20. Additionally the

25   transmitted data of the respective NAN response PDU 41, 42 is recorded. The communication user with this station address is then addressed with a NAN request PDU 36, 40, the contents of which correspond to the NAN response PDU 41, 42. The communication user thus continually has the assurance that it

30   is correctly identified by the ACFG manager 20 as exactly this ACFG agent and has been included in the system MIB 21.

If a station address is allocated simultaneously to several
ACFG agents 23, 24, an address conflict arises and the ACFG
manager 20 likewise receives no valid NAN response PDU and this
station address 31 would be characterized in its system MIB 21
5   as non-occupied.

If a NAN request PDU 39 is sent to a station address 32 used by
a communication user 26 not using the described method, this
communication user 26 will send a PDU 43 to the ACFG manager
10   20, which however contains none of this data uniquely
identifying this communication user 26. The communication user
26 is identified by the ACFG manager 20 as a communication user
without ACFG agent functionality. In this case the ACFG manager
20 will allocate the attribute "not an ACFG agent" to the
15   corresponding station address 32. The station address 32
continues to be addressed with a NAN request PDU - in this case
the same one as during the previous addressing.

Figure 5 shows the communication between a first communication
20   user and another communication user without an address
conflict. The first communication user, in accordance with
Figure 4 the ACFG manager 20 with a system MIB 21, sends data
packets to the ACFG agent 22 via a bus not shown here. Figure 5
shows two communication cycles for allocating station
25   addresses, the start of a communication cycle in each case
being indicated by a broken line. The time progression is again
symbolized by a time arrow t. In the first communication cycle
a NAN request PDU 36 is sent to the station address 29
allocated to the ACFG agent 22 after the mandatory SDD request
30   PDU 34. The ACFG agent 22 then sends a NAN response PDU 41 in
reply, containing information uniquely identifying this ACFG
agent 22. The ACFG manager 20 then in its system MIB allocates
to the station address 29 this information characterizing the

ACFG agent 22. In a second following communication cycle the
ACFG manager 20 sends the station address 29 a NAN request PDU
50 containing the information uniquely identifying the ACFG
agent 22. The ACFG agent 22 then recognizes that the ACFG
5   manager 20 has allocated it to the correct station address and
in reply again sends the NAN response PDU 41. Corresponding to
the second communication cycle further following communication
cycles are executed in respect of this station address and this
ACFG agent 22.
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Figure 6 shows the communication between a first communication
user and another communication user having no means for sending
second data packets. The first communication user, in
accordance with Figures 4 and 5 the ACFG manager 20 with a
15 system MIB 21, sends an SDD request PDU 34 in a first
communication cycle to all communication users by means of a
broadcast 27. The ACFG manager 20 sends a NAN request PDU 39 to
the station address 32. The communication user 26 to whom this
station address 32 is allocated has however no means for
20 sending second data packets having data uniquely identifying
the communication user and hence sends in reply a PDU 43 not
containing any data uniquely identifying this communication
user 26 or the communication user 26 sends no reply or no data
packet at all. The ACFG manager 20 then allocates the
25 information or attribute "not an ACFG agent" in its system MIB
to the respective station address 32. In all other further
communication cycles the ACFG manager 20 again sends a NAN
request PDU 39 to the station address 32 and in reply receives
from the communication user 26 in each case a PDU 43 not
30 containing data identifying this communication user.

Figure 7 shows the communication between a first communication
user and other communication users when an address conflict

occurs. Again several communication cycles are illustrated,
following one another in the direction of the time arrow t, the
start of which is indicated in each case by a broken line. The
first communication user in the exemplary embodiment according
5   to Figure 7 is again the ACFG manager 20 having a system MIB 21
for allocating information to station addresses. At the start
of each communication cycle shown here the ACFG manager 20
sends an SDD request PDU 34 by broadcast 27 to all station
addresses or all communication users containing the information
10   about non-occupied station addresses. In the first
communication cycle shown here the ACFG manager 20 sends a NAN
request PDU 38 to the station address 31. However, this station
address 31 is simultaneously allocated to two different ACFG
agents 23 and 24. The ACFG manager 20 then receives no response
15   PDU uniquely identifying an individual ACFG agent and hence
characterizes the station address 31 as non-occupied in its
system MIB 21.

In a second communication cycle this station address 31
20   characterized as non-occupied is therefore again sent a NAN
request PDU 38 by the ACFG manager 20 which does not contain
information uniquely identifying one of the two ACFG agents 23
or 24. Both ACFG agents 23 and 24 thereby recognize that they
could not be uniquely allocated to the station address 31 by
25   the ACFG manager 20 and then automatically select for
themselves a new station address 51 or 52 from the pool of
station addresses characterized as non-occupied which were
notified by broadcast 27 by means of the SDD request PDU 34.
Thus an address conflict is signaled in the ACFG agent 23, 24
30   if the ACFG agent 23, 24 does not receive the contents of its
own NAN response PDU after receipt of a NAN request PDU 38 in
the next ACFG cycle. In this case the ACFG agent 23, 24
withdraws from the bus and returns to the bus with a randomly

selected station address from its list of free station
addresses. This procedure is repeated until the station address
of the ACFG agent 23, 24 is recognized by the ACFG manager 20
and has been included in the system MIB 21 thereof.

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In the third communication cycle shown here the ACFG manager 20
will send these station addresses 51 and 52 previously
characterized as non-occupied a NAN request PDU 38 not
containing information uniquely identifying a communication
10   user. The ACFG agents 23 and 24 reply to this NAN request PDU
38 in each case with a NAN response PDU 53 or 54 containing
information uniquely identifying the respective ACFG agents 23
and 24. The ACFG manager 20 can then allocate the station
addresses 51 and 52 the corresponding information contained in
15   the NAN response PDUs 53 or 54. In the following communication
cycle the ACFG manager 20 then sends the respective station
address 51 or 52 NAN request PDUs 55 and 56 containing the
information uniquely identifying the respective ACFG agents 24
or 23. The ACFG agents 23 and 24 reply with the corresponding
20   NAN response PDUs 54 or 53.

All station addresses on which there is an address conflict can
have very different reactions depending on the bus system,
topology and configuration of the respective bus system. Within
25   the described procedure for autoconfiguration the reactions
described below are expected and overcome. In a first case the
ACFG manager 20 does not receive an answer from this station
address because the data packet has been so destroyed by
overlaying that no interpretation is possible. In this case
30   this station address is again addressed in the next ACFG cycle
with a NAN request PDU without corresponding data contents of
the ACFG agent. The ACFG agent recognizes that the
communication to the ACFG manager 20 was not successful and

automatically alters the station address thereof. In a second
case the ACFG manager 20 receives an unknown reply from this
station address because the data packet has been corrupted by
overlaying but not completely destroyed. In this case this
5   station address is addressed again in the next ACFG cycle with
a NAN request without corresponding data contents of the ACFG
agent. The ACFG agent also recognizes in this case that the
communication to the ACFG manager 20 was not successful and
automatically alters the station address thereof. In a third
10 case the ACFG manager 20 receives a correct NAN response PDU
from this station address, because one of the telegrams of the
different ACFG agents was able to prevail electrically on the
transmission medium. This behavior can be observed in the case
of particular topologies with very long bus lines, repeaters
15 or couplers for linking different physical media if an ACFG
agent is located very close to the ACFG manager 20 and another
ACFG agent is relatively far away or is located in another bus
segment. Very different response times emerge from this for the
two ACFG agents. In this case the ACFG manager 20 sends a NAN
20 request PDU in the next cycle with the data contents of one of
the ACFG agents. All other ACFG agents located on this station
address recognize that the communication to the ACFG manager 20
was unsuccessful and alter the station address thereof.

25 According to another exemplary embodiment all device
information needed for an automatic configuration is stored
directly in the memory of the ACFG agent. This memory can be
uniquely addressed via the bus from the ACFG manager 20 so that
the ACFG manager 20 can automatically read out all device
30 information needed for the configuration from the ACFG agents.
A message-oriented transmission method is used, for example,
for reading out, as already defined for most serial bus
systems. Thus an up-to-date picture of the device information

of every ACFG agent located on the serial bus is available in
the system MIB 21 of the ACFG manager 20 at all times. The
device information essentially consists of an identification
and possible configurations and parameterizations. On the basis
5 of this data, project planning of the serial bus is possible
without extra device information supplied by the manufacturer
in the form of electronic data sheets.

According to another embodiment it is possible to predefine
10 expected project planning data in the ACFG manager 20. In this
case the expected project planning data is compared to the
actual current status on the serial bus and any divergences are
displayed. This is visualized with the aid of corresponding
displays on all ACFG agents, so that project planning progress
15 and error events can be recognized in every part of a system.
Thus a project planner always has available a comparison
between the projected communication users with their
configuration and parameterization and the situation actually
prevailing on the serial bus. Thus project planning errors,
20 errors when setting up the bus system, errors in wiring and the
choice of communication users can be analyzed and
correspondingly rectified significantly more easily at one
central point.

25 When specifying expected project planning data it is possible
but not necessary to assign desired station addresses for all
communication users located on the bus. If station addresses
have been projected, they can be assigned very easily by the
ACFG manager 20 on the basis of the behavior when resolving
30 address conflicts. Within a few iteration steps across all
station addresses all projected station addresses can be
assigned one after the other. Address conflicts which then
arise again are resolved by the ACFG agents automatically. Only

those ACFG agents to which no projected station address has as
yet been allocated temporarily accept a random free station
address. All other ACFG agents retain their explicitly
allocated station address.

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Another embodiment of the method relates to the unique
identification of communication users where this is not
possible on the basis of the project planning data. In this
case an acyclic communication channel is opened between the

10   ACFG manager 20 and the ACFG agents which cannot be allocated
to the project planning. Manual identification takes place by
means of a sequence of read and write commands and
corresponding displays and input aids for the ACFG agents.

15   In summary, the invention thus relates to a method for
simplified allocation of station addresses 6 to communication
users 2 in a bus system 9, and communication users 1, 2 in a
bus system 9. Exactly one first communication user 1 able to
transmit automatically on the bus 3 can then allocate data to a

20   station address 6, said data uniquely identifying another
communication user 2 or characterizing a station address 6 as
non-occupied. Another communication user 2 that in an earlier
communication cycle already sent the first communication user 1
a data packet containing data uniquely identifying this

25   communication user 2 and that in a subsequent communication
cycle receives a data packet 10 containing data not uniquely
identifying this communication user 2 can automatically alter
the station address 6 thereof into a station address 6
characterized as non-occupied.